Title of Presentation: Bio-inspired design of lightweight and high-strength fiber reinforced polymer composites for structural applications

Zhong Hu

Department of Mechanical Engineering, South Dakota State University, Brookings, SD, USA

Abstract

The ever-increasing requirements for structural performance drive the research and development of lighter, stronger, tougher, and multifunctional composite materials, especially, the porous structures, heterogeneities, or hybrid composites have attracted great interest from the materials research community. However, the strong coupling among the material composition and topology of the porous structure hinders the conventional trial-and-error approaches, and current technologies that rely on traditional design and manufacturing techniques are insufficient to effectively solve the pressing challenges facing future societies. This presentation aims to adopt bio-inspired design for structural applications. Bio-inspired design solutions are widely used in different engineering disciplines. However, in structural engineering, these solutions are mainly limited to bio-inspired structures or microstructures, shapes or topologies, and materials, and the applications are mainly in optimizing stiffness, strength, light weight, toughness, etc. In this work, carbon fiber-reinforced polymer matrix composite materials were adopted for structural design. 2D and 3D periodic lattice blocks inspired by biomimetics combined with topological optimization based on finite element modeling and experimental approach were proposed. Computer modeling and topology optimization based on finite element analysis were conducted on the periodic representative volume elements to characterize the designed lattice structural composites' performance. 3D printing technique was used for prototyping the bio-inspired designed porous structures, and experimental tests were carried out for validating the design methodology. The proposed approach provides a design tool for more affordable, more effective, and higher-performance structural materials.

Keyword: biomimetics, topological optimization, carbon fiber reinforced polymer composite, computer modeling, finite element analysis, 3D printing, structural applications